L Number	Hits	Search Text	DB	Time stamp
1	197827	plugin or plug-in or (plug adj in) or module	USPAT	2004/02/17 10:14
2	145267	telephone or phone	USPAT	2004/02/17 10:15
3	7221	protocol with conver$5	USPAT	2004/02/17 10:17
4	9877	(plugin or plug-in or (plug adj in) or module) same (telephone or phone)	USPAT	2004/02/17 10:17
5	108	(protocol with conver$5) same ((plugin or plug-in or (plug adj in) or module) same (telephone or phone))	USPAT	2004/02/17 10:18
6	32	((protocol with conver$5) same ((plugin or plug-in or (plug adj in) or module) same (telephone or phone))) and 379/$.ccls.	USPAT	2004/02/17 10:18
7	95	((protocol with conver$5) same ((plugin or plug-in or (plug adj in) or module) same (telephone or phone))) and @ay<=1999	USPAT	2004/02/17 10:18
8	0	eigent and 379/$.ccls.	USPAT	2004/02/17 11:51
9	60	eigen$ and 379/$.ccls.	USPAT	2004/02/17 11:52
10	15195	subscriber with (loop or line)	USPAT	2004/02/17 11:52
11	1742479	physical or structure	USPAT	2004/02/17 11:52
12	14	(eigen$ and 379/$.ccls.) and (subscriber with (loop or line)) and (physical or structure)	USPAT	2004/02/17 12:10
13	319	linear adj operator	USPAT	2004/02/17 12:12
14	229	(physical or structure) and (linear adj operator)	USPAT	2004/02/17 12:11
15	1	(subscriber with (loop or line)) and ((physical or structure) and (linear adj operator))	USPAT	2004/02/17 12:11
16	0	(eigen$ and 379/$.ccls.) and ((physical or structure) and (linear adj operator))	USPAT	2004/02/17 12:12
17	0	(eigen$ and 379/$.ccls.) and (linear adj operator)	USPAT	2004/02/17 12:12
18	1	(linear adj operator) and 379/$.ccls.	USPAT	2004/02/17 12:12
19	12	(linear adj operator) and 324/$.ccls.	USPAT	2004/02/17 12:21
20	6109	(linear or integral) with operator	USPAT	2004/02/17 12:22
21	22	(subscriber with (loop or line)) and ((linear or integral) with operator)	USPAT	2004/02/17 12:22
22	14	(physical or structure) and ((subscriber with (loop or line)) and ((linear or integral) with operator))	USPAT	2004/02/17 12:22

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2	145267	telephone or phone	USPAT	2004/02/17 10:15
3	7221	protocol with conver$5	USPAT	2004/02/17 10:17
4	9877	(plugin or plug-in or (plug adj in) or module) same (telephone or phone)	USPAT	2004/02/17 10:17
5	108	(protocol with conver$5) same ((plugin or plug-in or (plug adj in) or module) same (telephone or phone))	USPAT	2004/02/17 10:18
6	32	((protocol with conver$5) same ((plugin or plug-in or (plug adj in) or module) same (telephone or phone))) and 379/$.ccls.	USPAT	2004/02/17 10:18
7	95	((protocol with conver$5) same ((plugin or plug-in or (plug adj in) or module) same (telephone or phone))) and @ay<=1999	USPAT	2004/02/17 10:18
8	0	eigent and 379/$.ccls.	USPAT	2004/02/17 11:51
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10	15195	subscriber with (loop or line)	USPAT	2004/02/17 11:52
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12	14	(eigen$ and 379/$.ccls.) and (subscriber with (loop or line)) and (physical or structure)	USPAT	2004/02/17 12:10
13	319	linear adj operator	USPAT	2004/02/17 12:12
14	229	(physical or structure) and (linear adj operator)	USPAT	2004/02/17 12:11
15	1	(subscriber with (loop or line)) and ((physical or structure) and (linear adj operator))	USPAT	2004/02/17 12:11
16	0	(eigen$ and 379/$.ccls.) and ((physical or structure) and (linear adj operator))	USPAT	2004/02/17 12:12
17	0	(eigen$ and 379/$.ccls.) and (linear adj operator)	USPAT	2004/02/17 12:12
18	1	(linear adj operator) and 379/$.ccls.	USPAT	2004/02/17 12:12
19	12	(linear adj operator) and 324/$.ccls.	USPAT	2004/02/17 12:21
20	6109	(linear or integral) with operator	USPAT	2004/02/17 12:22
21	22	(subscriber with (loop or line)) and ((linear or integral) with operator)	USPAT	2004/02/17 12:22
22	14	(physical or structure) and ((subscriber with (loop or line)) and ((linear or integral) with operator))	USPAT	2004/02/17 12:22
23	19	nguyen-duc.xp. and math$	USPAT	2004/02/17 13:49
25	3	one-ended and 379/$.ccls.	USPAT	2004/02/17 13:50
26	8	one-end$2 and 379/$.ccls.	USPAT	2004/02/17 13:51

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feedback filter by performing the linear signal transformation L_p.

This adaptive embodiment finally enables to further improve the already achieved transmission quality by adding a relatively simple non-adaptive post-detector to which the input signal of the symbol decision circuit is applied.

BRIEF DESCRIPTION OF THE DRAWING

The invention will be further explained hereinbelow with reference to the drawing, in which:

FIG. 1 shows a block diagram of a conceptual embodiment of a data transmission system in which the invention can be used;

FIG. 2 shows a functional discrete-time model of the system of FIG. 1 when conventional measures are employed;

FIG. 3 shows a functional discrete-time model of the system of FIG. 1 when the measures according to the invention are employed;

FIG. 4 shows a functional discrete-time model of an attractive embodiment of a system according to the invention; and

FIG. 5 shows a functional discrete-time model of an adaptive embodiment of a receiver of a system according to the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1 a block diagram is shown of a system for data signal transmission with a data transmitter 1, a transmission channel 2 and a data receiver 3. The data transmitter 1 comprises a data signal source 10 for generating a data signal. This data signal is converted by an encoder 11 into a data signal which is transmitted through transmission channel 2 at a symbol rate 1/T. The intersymbol interference (ISI) and noise developed during this transmission are combated in the data receiver 3. Thereto, data receiver 3 comprises an equalizer 30 of the decision feedback type which includes a feedforward filter 31 which is dimensioned for suppressing in the best way possible pre-cursive ISI and noise. On the basis of symbol decisions which are formed in a symbol decision circuit 32 a feedback filter 33 subsequently forms a cancelling signal for post-cursive ISI which is subtracted from the output signal of feedforward filter 31 by means of a difference circuit 34 for obtaining the input signal of symbol decision circuit 32. Finally, from the formed symbol decisions a decoder 35 forms a replica of the original data signal which is applied to a data signal sink 36.

To illustrate the problem for which the invention provides a solution, FIG. 2 shows a functional discrete-time model of the system of FIG. 1 when employing conventional measures. In the FIGS. 1 and 2 corresponding elements are denoted by the same reference symbols. The model of FIG. 2 is given for the case in which data signal source 10 generates a binary data signal and data transmitter 1 applies a ternary data signal to transmission channel 2.

A binary data signal d_k generated by data signal source 10 is converted by a non-linear part 12 of the encoder 11 into a likewise binary data signal a_k which, subsequently, by the linear part 13 of the encoder 11 is converted into a ternary data signal b_k to be applied to discrete-time transmission channel 2. To characterize the operation performed in this linear part 13 a partial-response polynomial $g_l(D)$ can be used, D being a delay

operator representing the symbol interval T. Further details about these partial-response polynomials are to be found, for example, in the article "Partial-Response Signaling" by P. Kabal and S. Pasupathy, IEEE trans. Commun., Vol. COM-23, No. 9, pp. 921–934, Sept. 1975. For explaining the following description it should be observed that such polynomials generally have a relatively low order and also, apart from an otherwise unimportant scale factor, only have integral-valued coefficients. In the present case, for the purpose of illustration, the bipolar response 1-D for the polynomial g_l (D) is chosen such that

$$b_k = a_k - a_{k-1}. \tag{1}$$

The ternary data signal b_k is converted into an output signal r_k by the cascade arrangement of transmission channel 2 and feedforward filter 31 in FIG. 1 according to

$$r_k = (b*(f*w))_k + (n*w)_k, \tag{2}$$

where the symbol "*" denotes the linear convolution-operator, f_k and w_k represent the discrete-time impulse responses of transmission channel 2 and feedforward filter 31, respectively, and n_k represents an additive discrete-time noise signal which is added by means of a summator 20.

With a proper dimensioning of the feedforward filter 31 of FIG. 1 it holds that the signal r_k contains virtually only post-cursive ISI. This implies that $(f*w)_k$ can significantly differ from zero only for non-negative instants k. In the present system post-cursive ISI is combated by making feedback filter 33 have a causal impulse response p_k for which holds

$$p_k = \begin{cases} 0, & k \leq 0, \\ (f*w)_k, & k \geq 1, \end{cases} \tag{3}$$

and applying to this feedback filter 33 the symbol decisions $\hat{b}_k$ which are formed by decision circuit 32. As a result of the causal character of feedback filter 33 its output signal is at any instant k only determined by symbol decisions $\hat{b}_{k-i}$ with $i \geq 1$ that have already been formed. Under normal operating conditions these symbol decisions are correct, so that the output signal of the feedback filter 33 can be described as

$$(\hat{b}*p)_k = (b*p)_k. \tag{4}$$

The output signal $\bar{b}_k$ of difference circuit 34 can now be described as

$$\bar{b}_k = r_k - (\hat{b}*p)_k. \tag{5}$$

In the case in which signal r_k only contains post-cursive ISI, this formula when utilizing formulas (2), (3) and (4) can be simplified to

$$\bar{b}_k = b_k + (n*w)_k = b_k + n_k'. \tag{6}$$

where n_k' represents the version of noise signal n_k that is attennuated in amplitued by feedforward filter 31. According to the latter formula, in the absence of error propagation, at the input of symbol decision circuit 32 an ISI-free estimate $\bar{b}_k$ is formed of the data signal b_k at the output of data transmitter 1.